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(54) LAMINATES OF CLOTH AND FILLED CRYSTALLINE
POLYPROPYLENE AND A METHOD FOR MAKING
THEM

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ABSTRACT OF THE DISCLOSURE: OCT 12 1982 1133369

Laminates comprising cloth (17) or other sheet material bonded to a filled crystalline polypropylene composition (14) by means of an unfilled crystalline polypropylene composition (15), preferably a crystalline random copolymer of propylene and 0.5 to 5.0% of ethylene. The laminates are made by sandwiching preferably a sheet (15) of the unfilled composition between the cloth (17) and filled composition (14) and then heating the sandwich to above the crystalline melting points of the polypropylenes and subsequently cooling to form the laminate. The fillers may be minerals or wood flour, the cloths may be knitted, woven or felted and other sheet materials may be plastics films, metal foils, paper or leather cloth.

LAMINATES OF CLOTH AND FILLED CRYSTALLINE POLYPROPYLENES
AND A METHOD FOR MAKING THEM

This invention relates to laminates of cloth or other sheet material and filled crystalline polypropylenes and 5 to a method of making them.

Crystalline polypropylenes often contain fillers to increase their stiffness and to reduce their shrinkage during crystallisation and sometimes to reduce costs. Unfortunately, fillers can reduce the adhesion of 10 polypropylene compositions to cloth or other sheet material and in particular cloth easily delaminates from a filled composition in concave regions of a shaped article made by thermoforming (for example, pressure forming including warm forging) a sheet of cloth/filled 15 polypropylene laminate.

German Offenlegungsschrift 2 727 285 discloses the lamination of cloth to filled polypropylenes and it improves adhesion between the cloth and filled polypropylene by using auxiliary heating and mineral 20 fillers of high specific heat so as to ensure that the composition remains very hot while it contacts the cloth. The process is less effective with fillers of high specific volume (e.g. wood flour despite its high specific heat). Also the use of very hot compositions promotes 25 oxidative degradation of the polypropylene and certain fillers, especially wood flour and further limits the range of heat-sensitive cloths which may be used.

Cloths or other sheet materials have been bonded adhesively to polypropylene, but commercial adhesives are 30 usually incompatible with crystalline polypropylene and so their use creates a significant line of weakness in the laminate. The problem is aggravated by differential contraction when the laminate cools.

It has now been discovered that adhesion can be 35 improved by interposing unfilled crystalline polypropylene



between the cloth or other sheet material and the filled crystalline polypropylene. Especially good improvements are obtained using random copolymers of propylene with amounts of ethylene which are small enough to allow the 5 copolymer to crystallise. For example, improved adhesion is obtained even when the filler is wood flour. The crystallinity of polypropylene is measured by X-rays by the method of Natta et al described in "Rendiconti dell' Academia dei Lincei" January 1957 pages 11 to 17 and for 10 the purposes of this specification propylene homopolymers or sequential copolymers are only considered to be "crystalline" if they are at least 40 (preferably 50)% crystalline as measured by the method of Natta et al.

Accordingly, this invention provides a laminate of 15 cloth or other sheet material and a filled crystalline polypropylene composition containing 20 to 80 (preferably 30 to 70)% by weight of a particulate filler characterised in that between the cloth or other sheet material and the filled composition is an unfilled crystalline 20 polypropylene composition. The percentage of filler is based on the total weight of the composition. The laminate may be in the form of a shaped article having concave curvatures of over 0.5 (for example 1 to 3) cm⁻¹ optionally made by thermoforming from sheet.

25 The crystalline polypropylene may be a homopolymer, sequential copolymer with up to 25 (preferably 7 to 18)% of other α-olefin or a random copolymer with up to 10 (preferably 0.5 to 5)% of other α-olefin. The percentage of comonomer is by weight based on the weight of the 30 copolymer. The preferred comonomer is ethylene. The polypropylene preferably has a melt flow index of from 0.1 to 40 (more preferably 0.5 to 10) g/10 minutes when measured prior to mixing with the filler. Melt flow index is measured according to British Standard 2782: Part 1: 35 Method 105C of 1970 using a 2.16 kg load and performed at

- 230°C. The polypropylene (usually the homopolymer) may be blended with up to 40% by weight (based on the weight of the polypropylene) of a rubbery material which improves the impact resistance of the polypropylene. Typical 5 rubbery materials include butyl rubbers, polyisobutylenes and amorphous rubbery copolymers of ethylene and propylene (especially when diene modified) as described in "Chemistry and Industry" 16 March 1974 pages 255 to 258.
- Typical sequential copolymers are made by adding 7 to 25% 10 by weight of ethylene to the closing stages of an otherwise propylene homopolymerisation when at least some of the ethylene/propylene chains may form as blocks on an otherwise homopolymer chain.
- Random copolymers are made by polymerising propylene 15 and for at least a major proportion of the polymerisation the propylene is mixed with the required amount of other α -olefin. Random copolymers of propylene and ethylene and containing some γ -crystallinity of the type described in "Makromolekulare Chemie" Volume 75 of 1964 pages 134 to 20 158 are preferred. Such crystalline random copolymers have good compatibility with crystalline homopolymers or sequential copolymers of propylene especially if the random copolymers are at least 40% crystalline by the method of Natta et al.
- Both the filled and unfilled polypropylene 25 compositions may contain up to 7% by weight of the polypropylene of non-filler additives such as stabilisers (e.g. antioxidants or light stabilisers), soaps and lubricants (e.g. metal stearates) and pigments (e.g. 30 titania or carbon black).
- The particulate fillers should preferably pass through ASTM Sieve 40 (420 μ) and desirably mineral fillers should have a particle size of from 1 to 25 μ . The compositions preferably contain 45 to 70% of mineral 35 filler or 30 to 50% of organic (including fibrous) filler.

Typical mineral fillers include chalk, limestone, dolomite, gypsum, barytes, talc, slate flour, clay, mica or pulverised fuel ash, all of which may be treated with coupling agents. However, fibrous organic fillers such as
5 wood flour are preferred because of their lower density and lower abrasiveness. Wood flour usefully has a particle size of 100 to 350 μ .

The cloth may, for example, comprise knitted, woven or felted fibres of cotton, wool, glass, polypropylene,
10 nylon, polyethylene terephthalate, polyacrylate or mixtures of two or more such fibres. A very suitable cloth comprises a needle-tufted non-woven mat of different fibres (preferably polyester and nylon). A suitable polyester is polyethylene terephthalate optionally
15 containing up to 10% by weight of the polyester of copolymerised isophthalic acid. Melded cloth sold as 'Cambrelle' (i.e. cloth comprising fusion-bonded conjugate fibres as described, for example, in British patent specification 1 078 181) is also suitable. The surface of
20 the cloth which is not destined to be bonded to the polypropylene may be bonded to a layer of other material. For example, it may be coated with a moderately heat-sensitive optionally foamed thermoplastics material such as plasticised polyvinyl chloride to provide a leather-like decorative finish on the laminate. Alternatively, a
25 foamed interlayer may be inserted between the cloth and a layer of plasticised polyvinyl chloride. Other sheet materials include plastics films (especially optionally metallised films of polyethylene terephthalate or the
30 like), metal foils or paper (especially when printed to simulate the appearance of wood).

The laminate can be made by:

- a) heating the filled and unfilled polypropylene compositions to temperatures above the crystalline melting points of their polypropylenes,

- b) contacting a surface of the filled composition with a surface of the unfilled composition before, during or after heating,
- c) contacting the cloth or other sheet material with another surface of the unfilled composition under conditions of temperature and pressure such that some unfilled composition flows into the cloth or into intimate contact with the other sheet material and then
- 10 d) cooling the filled and unfilled compositions to below their crystalline melting points whereupon the unfilled composition bonds the cloth or other sheet material to the filled composition to form the laminate.
- 15 Preferably at least some of the heat used to heat the unfilled composition is supplied by the heated filled composition when the two compositions are in contact.
Specific procedures for making the laminates will now be described with reference to the drawings of which:
- 20 Figure 1 is an elevation of a three roll stack and components of a laminate;
- Figure 2 is a section of a thermoforming press containing components of a laminate;
- Figure 3 is a section of a laminate made in the press shown in Figure 2;
- 25 Figure 1 illustrates a procedure for making a flat laminate using a stack of three rolls 11, 12 and 13. A sheet 14 of filled polypropylene composition is extruded from a die 10 and fed to the nip between rolls 11 and 12
- 30 while the sheet 14 remains at a temperature above the crystalline melting point of the polypropylene. A web 15 of unfilled polypropylene is unwound from reel 16 and cloth 17 is unwound from reel 18. Web 15 and cloth 17 are also fed to the nip between opposed rollers
- 35 11 and 12 such that web 15 is sandwiched between sheet 14

and cloth 17. The temperature of roll 12 is adjusted to retard cooling of sheet 14 so that heat from sheet 14 raises the temperature of web 15 above the crystalline melting point of the polypropylene in the unfilled 5 composition so that on or short after being nipped between opposed rollers 11 and 12, region 20 fuses with the upper surface region 19 of sheet 14 and the boundary between them becomes insignificant. Heat from sheet 14 also softens the upper surface region 21 of web 15 so that when 10 nipped between opposed rollers 11 and 12, unfilled composition flows into some of the interstices (not shown) of cloth 17. On cooling the laminate 22 is formed.

The dashed lines 23 shown in Figure 1 indicate a modified procedure in which cloth 17 is fed to the nip 15 between opposed rollers 12 and 13. This modification can be of benefit when using heat-sensitive cloths.

Die 10 may be replaced by any convenient source of hot extruded sheet, for example, a calender.

By omitting cloth 17, the procedure described with 20 reference to Figure 1 may be used to make a composite of filled and unfilled compositions to which cloth can be laminated in some subsequent operation such as a pressing operation as hereinafter described with reference to Figure 2. Although this involves a second step in the 25 making of the laminate, it does allow greater flexibility in choice of cloth and the possibility of recycling off-cuts left when particular shapes of composite are cut from the sheet produced by rolls 11, 12 and 13. Accordingly, this invention also provides a composite 30 comprising a layer of filled crystalline polypropylene composition bonded to a layer of unfilled crystalline polypropylene composition.

The sheet of filled polypropylene composition conveniently has a thickness of from 0.5 to 5 mm and 35 preferably of 1 to 3 mm. The web of unfilled

polypropylene composition preferably has a thickness of 25 to 75 μ . Webs of a copolymer comprising 1.5 to 4% of randomly copolymerised ethylene and having a thickness of 25 to 75 μ are preferred because their use together with a
5 careful adjustment of the temperatures of the extruded sheet 14 and of roll 12 greatly facilitates the lamination of heat-sensitive cloths such as polypropylene cloths in general or cotton cloths coated with (optionally foamed) plasticised polyvinyl chloride. Lamination of heat-
10 sensitive cloths using unfilled compositions comprising homopolymers or sequential copolymers is more difficult.

Instead of using a web, the unfilled composition may optionally be pre-coated onto the cloth. Such coated cloths can also be thermoformed into preforms having
15 complex shapes so giving rise to a possible modification of this invention in which molten plastics composition (filled or unfilled) is injection moulded onto unfilled composition of the preform. The modification facilitates production of articles of complex shape and reduces the
20 risk of total penetration of the cloth by plastics material during an injection moulding process. The unfilled coating creates a stiff preform which is more easily positioned in an injection mould. An injection moulded unfilled plastics material is preferably the same
25 as the unfilled composition of the coating on the preform except that the coating material preferably has a lower melt flow index. If a filled composition is injection moulded on the preform, then preferably the coating comprises a random copolymer.

30 Figure 2 illustrates an alternative procedure for making a laminate using a thermoforming tool having a plug 31 and cavity 32 parts of a thermoforming tool. Inserted between plug 31 and cavity 32 is a sandwich consisting of cloth 33, sheet of unfilled polypropylene
35 composition 34 and sheet of filled polypropylene

composition 35. The sandwich lies between jaws 36 and 37 of a fixed clamp (not shown).

To make the shaped laminate shown in Figure 3, sheets 34 and 35 of unfilled and filled polypropylene 5 compositions respectively are inserted between plug 31 and cavity 32 and between jaws 36 and 37. Jaws 36 are closed to hold sheets 34 and 35. Infra-red heaters (not shown) are moved into positions above and below the pair of sheets 34 and 35 and used to heat sheets 34 and 35 to a 10 temperature in the vicinity of the crystalline melting points of the polypropylenes of the sheets. The heaters are withdrawn and cloth 33 is laid on sheet 34 with its edges between jaws 37 which are then closed to grip the sandwich. Plug 31 and cavity 32 are brought together so 15 that plug 31 enters cavity 32 causing the sandwich to conform to the shape of plug 31 and cavity 32. Pressure exerted by plug 31 and cavity 32 forces softened unfilled composition from sheet 34 into interstices (not shown) in cloth 33 and also promotes intimate contact between the 20 unfilled and filled compositions of sheets 34 and 35. On cooling, the boundary between sheets 34 and 35 becomes insignificant and as the polypropylene compositions solidify, cloth 33 becomes bonded to sheet 35 by means of the unfilled composition of sheet 34 to produce 25 the laminate shown in Figure 3. In particular, cloth 33 is bonded to sheet 35 even in radiussed portions 38 which have a curvature of 1 cm^{-1} .

If cloth 33 is not heat-sensitive, it can be laid on sheet 34 before heating so avoiding the need for jaws 36. 30 Sheets 34 and 35 may be replaced by a composite sheet comprising a layer of filled composition bonded to a layer of unfilled composition made for example by the procedure described with reference to Figure 1 but modified by the omission of cloth 17.

The procedures described with reference to Figure 2 may be modified by heating sheet 35 (or a corresponding composite) solely or mainly by heaters positioned below sheet 35. Although this is a slower operation, it does 5 permit greater tolerance of heat-sensitive cloths, especially if the unfilled composition comprises the most preferred random copolymers in thicknesses of 25 to 75 μ .

Flat laminates suitable for thermoforming can be made by replacing plug 31 and cavity 32 by a pair of opposed 10 flat plattens. Flat laminates made by the procedure described with reference to Figure 1 can be converted into shaped laminates using the plug and cavity method described with reference to Figure 2.

The invention is further illustrated by the following 15 examples of which 1b, 2b and 5b are comparative.

EXAMPLES 1 TO 6

Laminates were made by the procedure described with reference to Figure 1 of the drawings in which various cloths (as specified in Table 1) were nipped between the 20 bottom two rolls of a three roll stack. The top roll was maintained at 95°C, the middle roll at 100°C and the bottom roll at 105°C.

A composition comprising by weight:

25 40% wood flour and
 60% of a suitably stabilised polypropylene of
 melt flow index 1.5 g/10 minutes which was a
 sequential copolymer of propylene and
 15 % ethylene.

30 was extruded into sheet 2 mm thick at a temperature of
 195 to 205°C and transferred a distance of 0.1 m at room
 temperature to the bottom nip of the three roll stack. A
 web 50 μ thick of an unfilled random copolymer of
 γ -crystalline propylene and 2% ethylene of melt flow index

4.0 g/10 minutes was pressed onto the extruded sheet by the bottom nip which also pressed the cloth onto web of random copolymer. The sheets and cloth had a residence time of 20 seconds on the stack and on leaving the stack 5 they cooled to room temperature forming a laminate which could be thermoformed in a press of the type illustrated in Figure 2 without delamination of the cloth in the radiussed portions.

TABLE 1

Example	Propylene polymer	Cloth	Delamination
1a	Random copolymer	Knitted cotton	Slight on sharp radii
1b	None	Knitted cotton	Yes
2a	Random copolymer	Polyester/polyamide knitted cloth	No
2b	None	Polyester/polyamide knitted cloth	Yes
3	Random copolymer	Melded cloth based on nylon 6/nylon 6 conjugate fibres	No
4	Random copolymer	Felted polypropylene fibres	No
5a	Random copolymer	Textile cloth coated with plasticised polyvinyl chloride	No
5b	None	Textile cloth coated with plasticised polyvinyl chloride	Yes
6	Random copolymer	Needle-tufted non-woven mat of a mixture of fibres of nylon 6 with fibres of polyethylene terephthalate.	No

EXAMPLE 7

- A laminate was made by the procedure of Example 1a except that the filled polypropylene composition contained 40% by weight chalk having a particle size of from 1 to 5 25 μ instead of the wood flour and the knitted cotton cloth was coated with plasticised polyvinyl chloride on the surface not to be laminated to the polypropylene. A laminate was obtained in which the cloth was firmly bonded to the remainder of the laminate.
- 10 The procedure was repeated except that the web of random copolymer was omitted. A laminate was obtained in which the cloth was easily peeled from the filled polypropylene composition.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A laminate of cloth or other sheet material and a filled crystalline polypropylene composition containing 20 to 80% by weight of a particulate filler wherein
5 between the cloth or other sheet material and the filled composition is an unfilled crystalline polypropylene composition.
2. A laminate according to claim 1 wherein the unfilled crystalline polypropylene composition comprises a
10 random copolymer of propylene with up to 10% (by weight of the copolymer) of ethylene.
3. A laminate according to claim 2 wherein the random copolymer contains some γ -crystallinity.
4. A method for making a laminate as claimed in
15 claim 1 wherein the method comprises:
 - a) heating the filled and unfilled polypropylene compositions to temperatures above the crystalline melting points of their polypropylenes,
 - b) contacting a surface of the filled composition
20 with a surface of the unfilled composition before, during or after heating,
 - c) contacting the cloth or other sheet material with another surface of the unfilled composition under conditions of temperature and pressure such that
25 some unfilled composition flows into the cloth or into intimate contact with the other sheet material and then
 - d) cooling the filled and unfilled compositions to below their crystalline melting points whereupon
30 the unfilled composition bonds the cloth or other sheet material to the filled composition to form the laminate.

5. A process according to claim 4 wherein the filled composition, the unfilled composition and the cloth or other sheet material are brought into intimate contact by nipping between opposed rollers.

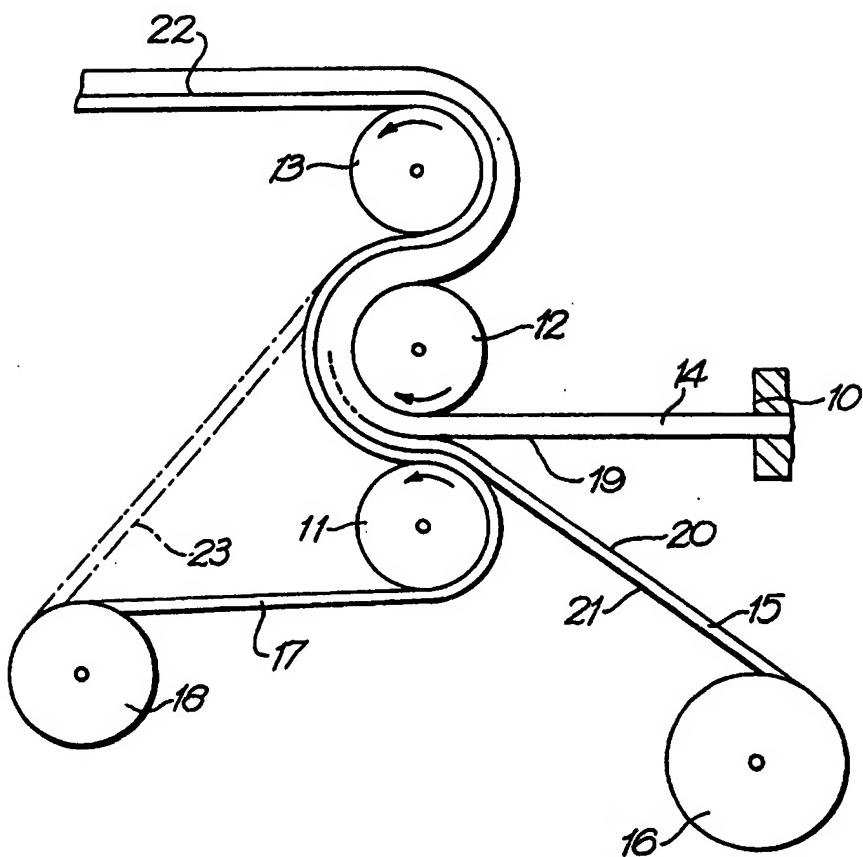
- 5 6. A process according to claim 4 wherein the unfilled composition is provided as a web sandwiched between a sheet of filled composition and cloth or other sheet material, the sandwich is located between opposed plug and cavity components of a thermoforming tool and the
10 opposed surfaces of the components of the sandwich are brought into intimate contact by advancing the plug into the cavity.



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Fig. 1.



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Fig. 2.

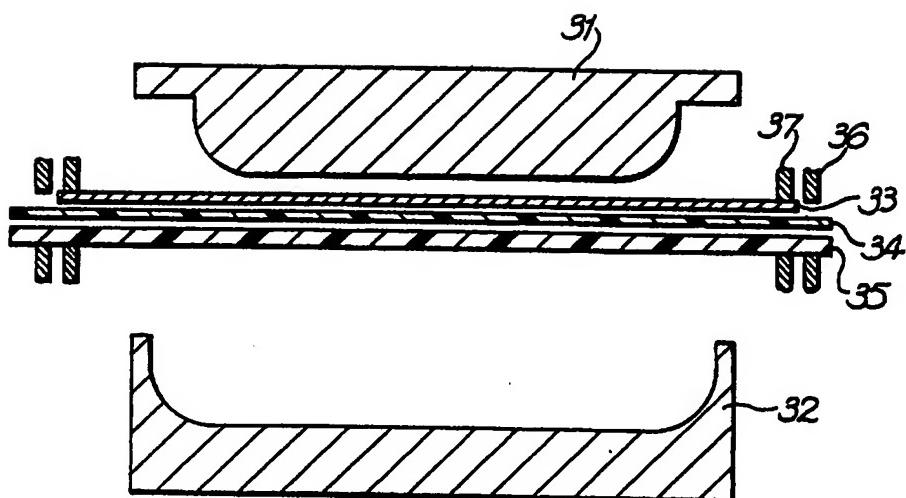


Fig. 3.



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